VERIFICATION OF TRANSLATION

Re: JAPANESE PATENT APPLICATION NO.2002-139609

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hereby declare that I am the translator of the document attached and certify that the following is true translation to the best of my knowledge and belief.

Signature of translator Tomoko Maeda
Tomoko MAEDA

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[Title of the Invention] FABRICATION METHOD OF NITRIDE SEMICONDUCTOR DEVICE

[Claims]

[Claim 1]

A method for fabricating a nitride based semiconductor light emitting device comprising the steps of:

forming an $Al_uGa_vIn_wN$ crystal ($u+v+w=1$) so as to have a concave portion;

covering at least a portion of the bottom and sidewalls of the concave portion with a dielectric film, amorphous insulator film or metal; and

regrowing an $Al_xGa_yIn_zN$ crystal ($x+y+z=1$) using a region of the $Al_uGa_vIn_wN$ which is not covered with the dielectric film or amorphous insulator film as a seed crystal.

[Claim 2]

A method for fabricating a nitride based semiconductor light emitting device according to Claim 1, wherein, in regrowing the $Al_xGa_yIn_zN$ crystal ($x+y+z=1$), an air gap is formed on the seed crystal having at least a portion of the bottom or sidewalls of the concave portion covered with a dielectric film, amorphous insulator film or metal, using the difference in the growing speed between the crystal face mainly composed of group III elements and the growing speed of the crystal face mainly composed of group V elements.

[Claim 3]

A method for fabricating a nitride based semiconductor light emitting device comprising the steps of:

forming an $Al_uGa_vIn_wN$ ($u+v+w=1$) crystal so as to have a concave portion;

covering at least a portion of the bottom and sidewalls of the concave portion with a dielectric film, amorphous insulator film or metal; and

growing a layered structure comprising a first cladding layer, active layer, and second cladding layer using the portion exposed from the $Al_uGa_vIn_wN$ as a seed crystal.

[Claim 4]

A method for fabricating a nitride based semiconductor light emitting device comprising the steps of:

recessing a portion of $Al_uGa_vIn_wN$ ($u+v+w=1$) on a substrate so as to have a striped shape by varying the processing period;

covering at least a portion of the bottom and sidewalls of the concave portion with a dielectric film, amorphous insulator film or metal; and

growing a layered structure comprising a first cladding layer, active layer, and second cladding layer using the portion exposed from the $Al_uGa_vIn_wN$ as a seed crystal.

[Claim 5]

A method for fabricating a nitride based semiconductor light emitting device according to Claim 4, wherein the region in which the processing period is varied is beneath the region to which a metal wire for supplying electric current to the layered structure is bonded.

[Claim 6]

A method for fabricating a nitride based semiconductor light emitting device according to any one of Claims 1 to 5, wherein the region which is not covered with the dielectric film or amorphous insulator film is a C-plane of the $Al_xGa_yIn_zN$ crystal ($x+y+z=1$).

[Claim 7]

A method for fabricating a nitride based semiconductor light emitting device according to Claim 4, wherein, in the $Al_uGa_vIn_wN$ ($u+v+w=1$) on the substrate, the width of the air gaps beneath the region where a wire for supplying electric current is formed is different from that of the other region.

[Claim 8]

A method for fabricating a nitride based semiconductor light emitting device according to Claim 4, wherein, in the $Al_uGa_vIn_wN$ ($u+v+w=1$) on the substrate, air gaps are formed in the region except for the portion beneath the region in which a wire for supplying electric current is formed.

[Claim 9]

A nitride based semiconductor light emitting device comprising an $Al_aGa_bIn_cN$ crystal layer ($a+b+c=1$) formed on a substrate, an $Al_dGa_eIn_fN$ crystal layer ($d+e+f=1$) formed above the $Al_dGa_eIn_fN$ crystal, and an active layer formed above the $Al_aGa_bIn_cN$ crystal layer, wherein a first air gap and a second air gap are formed between the $Al_aGa_bIn_cN$ crystal layer and the $Al_dGa_eIn_fN$ crystal layer, the width of the first air gap differs from that of the second air gap.

[Claim 10]

A nitride based semiconductor light emitting device comprising an $Al_aGa_bIn_cN$ crystal layer ($a+b+c=1$) formed on a substrate, an $Al_dGa_eIn_fN$ crystal layer ($d+e+f=1$) formed above the $Al_aGa_bIn_cN$ crystal layer, an active layer formed above the $Al_dGa_eIn_fN$ crystal layer, and an electrode formed on the active layer, wherein a wire for supplying electric current is electrically connected to the electrode, and air gaps are formed only the region other than the portion beneath the region between the $Al_aGa_bIn_cN$ crystal layer and the $Al_dGa_eIn_fN$ crystal layer to which the wire is connected.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Pertains]

The present invention relates to GaN-based semiconductor light emitting devices such as light emitting diodes, laser diodes, etc., which emit light at a range from ultraviolet to blue, green, orange, white or the like visible light, which are usable as displays, luminaries, and in the field of optical information processing, etc.; and to a fabrication method therefor.

[0002]

[Prior Art]

Semiconductors that contain nitrogen (N) as the Group V element are excellent candidates as useful materials for short-wavelength light emitting devices because of their wide band gap. Among these, extensive research has been conducted on gallium nitride based compound semiconductors (GaN based

semiconductors: $Al_xGa_yIn_zN$ ($0 \leq x, y, z \leq 1, x+y+z=1$)), and blue and green light emitting diodes (LED) have already been put to practical use. Furthermore, a semiconductor laser with oscillation wavelength in the 400-nm band is in strong demand to increase the storage capacity of optical disc apparatuses. For this reason, semiconductor lasers using GaN-based semiconductors have attracted widespread attention, and are now approaching a level of practical use.

[0003]

Fig. 4 is a cross-sectional view showing the structure of a currently in-use GaN based ultraviolet light emitting diode. A u-GaN seed crystal 42 ("u-" indicates undoped) is grown on a sapphire substrate 41 using a metal organic vapor phase epitaxy (MOVPE) techniques. Thereafter, dielectric masks 54 are selectively deposited in a striped pattern. Then, to obtain a flat surface, u-GaN 43 is regrown by a lateral overgrowth technique. Subsequently, an n-GaN contacting layer 44 ("n-" indicates n-type), u-GaN 45, InGaN active layer 46, p-AlGaN gap layer 47 ("p-" indicates p-type), and p-GaN contacting layer 48 are sequentially deposited. A mask having a predetermined shape is then formed on the surface of the p-GaN contacting layer 48, and then etched to expose a portion of the n-GaN contacting layer 44 to obtain an n-electrode 53. Then, by following a conventional method, a p-type electrode 49 and an n-electrode 53 are formed on the p-GaN contacting layer 48 and the n-GaN contacting layer 44, respectively. Finally, a gold wire 52 is bonded to the p-type electrode 49, via the base electrode 50 and a gold ball 51. In the same manner, a gold wire 52 is attached to the n-type electrode 53 via a gold ball 51. In this light emitting diode, the p-type electrode is formed from a transparent and conductive thin film, wherein the p-type electrode thereof becomes an emission detection surface by applying electric current from the p-type electrode to the entire surface of the p-type electrode. By making the p-type electrode side the emission detection surface, wire bonding becomes possible when a light-emitting diode is fabricated

after production of a semiconductor device. As a result, compared to a face-down mounting method, wherein bonding is conducted on the p-type electrode side by turning the device upside-down, this method is advantageous in that the device can be miniaturized and there is no need for accurate alignment, improving productivity.

[0004]

Sapphire, SiC, NGO, etc., are used as substrates for GaN based crystals; however, none of these substrates have a lattice constant that matches that of GaN, making it difficult to obtain coherent growth.

[0005]

Therefore, in a GaN layer that has been grown on such a substrate, a large number of dislocations (edge dislocations, screw dislocations, mixed dislocations) exist. For example, when a sapphire substrate is used, there exist approximately 1×10^9 cm^{-2} dislocations. These dislocations decrease the luminous efficiency of an ultraviolet light emitting diode.

[0006]

As a method for decreasing the dislocation density, the epitaxial lateral overgrowth (ELO) technique has been proposed. This method is effective in decreasing the number of threading dislocations in a system having a large lattice mismatch.

[0007]

Fig. 5 schematically shows the distribution of dislocations in a GaN crystal that has been obtained by ELO. First, GaN crystal 56 is deposited on a sapphire substrate 55 by MOVPE, etc. After depositing SiO_2 57 by CVD, etc., the SiO_2 57 is formed into a striped shape having a periodic pattern by photo lithography and etching. The GaN layer 58 is deposited by the ELO using the exposed portion of the GaN 56 as a seed crystal. As an overgrowth technique, MOVPE or HVPE can be employed. A large number of dislocations exist in the region 60 located above the seed crystal, wherein the dislocation density thereof is approximately 1×10^9 cm^{-2}. In contrast, the

region 59 that has laterally overgrown has fewer dislocations, wherein the dislocation density thereof is decreased to approximately 1×10^7 cm^{-2}. The width of the SiO_2 mask is approximately 4 μm and the intervals thereof are approximately 12 μm. Employing ELO makes it possible to form a substrate that has a low dislocation density, improving the luminous efficiency of the ultraviolet light emitting diode.

[0008]

[Problem to Be Solved by the Invention]

However, a conventional light emitting diode having such a structure, in which the emission detection surface is on the p-type electrode side, renders a problem in that light from the active layer cannot be effectively emitted because the light emitted to the n-type electrode, which is located opposite the p-type electrode, scatters or is absorbed.

[0009]

Even when ELO is conducted using a dielectric film, there is loss in light emission on the substrate side.

[0010]

The present invention aims at solving the above drawbacks and providing a method for fabricating a nitride semiconductor device, in particular a light-emitting diode that comprises a p-type electrode serving as an emission detection surface, that achieves higher luminous efficiency at a fabrication yield.

[0011]

[Means for Solving the Problem]

A method for fabricating a nitride based semiconductor of the present invention comprises the steps of forming an $Al_uGa_vIn_wN$ crystal ($u+v+w=1$, hereinafter referred to as AlGaInN) so as to have a concave portion, covering at least a portion of the bottom and sidewalls of the concave portion with a dielectric film, amorphous insulator film or metal, and regrowing an $Al_xGa_yIn_zN$ crystal ($x+y+z=1$) using a region of the $Al_uGa_vIn_wN$ which is not covered with the dielectric film or amorphous insulator film as a seed crystal. When the AlGaInN

is regrown, AlGaInN-based crystal is laterally overgrown and, air gaps are formed between partially covered crystal seed that was formed so as to have a concave shape and regrown AlGaInN using the difference in the growing speed between the crystal face mainly composed of group III elements such as Al, Ga, In, etc., and the growing speed of the crystal face mainly composed of group V elements.

[0012]

The fabrication method of the present invention comprises the steps of forming a nitride crystal so as to have a concave shape, covering at least a portion of the bottom and sidewalls of the concave portion with a dielectric film, amorphous insulator film or metal, and growing a layered structure comprising a first cladding layer, active layer, and second cladding layer using the portion exposed from the nitride crystal as a seed crystal. Also in this case, as the same as the above-described fabrication method, air gaps are provided beneath the AlGaInN crystal. By forming air gaps, it is possible to form an interface between the layered structure and air beneath the layered structure.

[0013]

The fabrication method of the present invention comprises the steps of recessing a portion of a wafer of a nitride based crystal so as to have a striped shape by varying the processing period, covering at least a portion of the bottom and sidewalls of the concave portion with a dielectric film, amorphous insulator film or metal, growing a layered structure comprising a first cladding layer, active layer, and second cladding layer using the portion exposed from the nitride based crystal as a seed crystal, and bonding an electrode and a metal wire for supplying electric current to the region formed into a concave shape by varying the processing period. In this case, air gaps are formed beneath the layered structure, in particular, beneath the portion to which the metal wire is bonded, by making the volume of the air gaps relatively small compared to other region to increase the structural strength of the crystal,

reducing the structural damage caused by the wire bonding.

[0014]

[Mode for Carrying Out the Invention]

Hereunder, a semiconductor light emitting device according to one embodiment of the present invention will be explained with reference to the drawings. The method for growing nitride based semiconductor employed in the present invention is not limited to the MOVPE, and any method proposed until now including hydride vapor phase epitaxy (HVPE) techniques, molecular beam epitaxy (MBE) techniques, etc., can be employed.

[0015]

Fig. 1 is a cross-sectional view showing a structure of a nitride based semiconductor light emitting device of the present embodiment.

[0016]

The method for fabricating the nitride based semiconductor light emitting device shown in Fig. 1 is as follows.

[0017]

First, TMG and NH_3 are applied to a C-plane sapphire substrate 11 at approximately 500° C to form an AlGaN buffer layer. Then, the temperature is raised to approximately 1020° C and TMG and NH_3 are supplied to form a u-GaN layer 12 having a thickness of approximately 1 μm. In this case, the principal plane (facing surface) is a C-plane.

[0018]

The resist is processed by photolithography into a striped pattern extending in the $\langle 1-100 \rangle_{GaN}$ direction. Subsequently, the u-GaN layer 12 is processed to form a recessed shape (concave portion) by dry etching. The height-difference is approximately 5000Å. In this case, as described latter, in those regions other than beneath the gold wire 23 for supplying electric current and the ball 22 to which the gold wire 23 is bonded, the width of the concave portions is approximately 12

μm, and the width of the ridge portions (the portions with resist) is approximately 3 μm. In those regions other than beneath the gold wire 23 for supplying electric current and the ball 22 to which the gold wire 23 is bonded, the width of the concave portions is approximately 3 to 6 μm, and the width of the ridge portions (the portions with resist) is approximately 3 μm. In other words, the width of the concave portions is different in the region beneath the wire for supplying electric current (gold wire) and other regions. In this embodiment, the ratio of the width of the concave portions in the region beneath the wire for supplying electric current to the width of the concave portions in other region is 12:3-6 . In other words, in $Al_uGa_vIn_wN$ ($u+v+w=1$) on the substrate, the width of the air gaps beneath the region in which a wire for supplying electric current is formed differs from the width of the air gaps in other regions.

[0019]

Subsequently, after depositing an Si_3N_4 film (not shown) by the electron cyclotron resource (ECR) sputtering method, the striped resist and the Si_3N_4 film formed thereon are removed by lift-off. Then, using the exposed u-GaN layer 12 as a seed crystal, a u-GaN layer 13 is regrown by MOVPE technique.

[0020]

In this case, the u-GaN layer 13 is regrown using the top surfaces of the principal plane (facing surface (C-plane)) of the GaN layer of the striped ridge portion of the u-GaN layer 12 as a seed crystal. In particular, the principal plane of the GaN layer grown by the MOVPE method is mainly composed of a Ga atomic plane, and when the GaN layer is regrown from the top surfaces of striped redge portion of the GaN, the GaN layer first regrows in the c-axis direction, and then laterally overgrows with extending in the c-axis direction and a-axis direction (i.e., $\langle 11-20 \rangle_{GaN}$ direction) using the C-plane and A-plane of the GaN, which was obtained by regrowing the GaN layer, as seed crystals. Thus, wing regions (regions regrowing in the

a-axis direction relative to crystal seed) are formed. In this case, the bottom surface of the wing region 131 of the u-GaN layer 13 laterally overgrown is mainly formed from an N atomic plane. On the N atomic plane, the crystal grows at an extremely slow speed compared to that of the opposite surface (Ga atomic plane). Therefore, substantially no crystal growth can be observed on the bottom surfaces of the wing regions. Accordingly, an air gap (cavity) 113 is formed between the u-GaN layer 13 and the concave portion. By using the C-plane as seed crystal, symmetrical wings extending from the seed crystals into the air are formed. As far as the air gap can be formed, the principal plane of the seed crystals may be slightly tilted either in the <1-100> direction or <11-20> direction relative to the C-plane. In the above-described regrowth technique, the mask in the concave portion may be formed from materials other than a Si_3N_4 film, and usable examples include dielectric films made of SiO_2 or the like, and metals having a high-melting point such as W (tungsten), etc., as long as selective growth is achievable. It is preferable that a selective growth mask formed from the above-mentioned dielectric film, metals having a high-melting point or the like be deposited on the entire surfaces of the bottom or side walls of the concave portion; however, even when there is a portion in which the mask is not formed, it is possible to form the air gap 13 by suitably selecting the conditions for the MOVPE for growing the u-GaN layer 13.

[0021]

One of characteristics of the regrowth technique of the present embodiment is such that air gaps are formed beneath the u-GaN layer 13, and the width of the concave portions is varied in a region (wire bonding region). In the region where the width of the concave portions is small, the adjacent wing regions come into contact with each other faster than in the regions where the width of the concave portions is large. However, even when such differences in timing arise, by suitably selecting the conditions for MOVPE during the formation of the

u-GaN layer, it is possible to make the surface of the substrate smooth and flat because of the migration of the supplied source gas over the surface of the crystal.

[0022]

Usually, the thickness of the u-GaN layer 13 is approximately 5 μm. The width of the sapphire substrate 11 shown in Fig. 1 is approximately 350 μm, and the width of the region to which a gold wire 23 is attached by wire bonding is approximately 50 μm.

[0023]

On the u-GaN layer 13, a u-GaN 14, n-GaN 15, u-GaN 16, InGaN active layer 17, p-AlGaN 18, and p-GaN 19 are sequentially deposited. Subsequently, selective etching is conducted to expose a portion of the n-GaN layer 15, and then, a p-electrode 20 and n-electrode 24 are formed. A base electrode 21 is formed on the p-electrode 20, and the gold wire 23 is attached to the p-electrode 20 and n-electrode 24 by wire bonding via a gold ball 22.

[0024]

Providing air gaps in a nitride based semiconductor light emitting device as in the present embodiment has three characteristics (advantages) compared to the case where crystal is grown directly on a sapphire substrate as in a conventional method or a light emitting device is fabricated using the ELO technique.

[0025]

The first characteristics is that, by providing air gaps, selectively and laterally overgrown wing regions do not directly come in contact with the mask for use in selective overgrowth. As a result, the selectively and laterally overgrown wing regions are formed in a stress-free condition. Therefore, in a wing region, irregularity of the orientation of the azimuthal axes in the c-axis crystals is not observed, and connection between wings can be smoothly performed. As a result, formation of additional crystals can be prevented. In other words, employment of the air gap makes it possible to

obtain a high-quality crystals having a regular orientation with a low deficiency in the region other than the ridge seed crystal portions (i.e., entire wing region). This characteristic is different from that of the ELO technique which is conventionally used to reduce the dislocation density. In the conventional ELO technique, a mask is formed between the regrown wing region and seed crystal, and this causes interfacial stress between the wing region and mask portion. This arises problems in that the orientation of the azimuthal axes in the c-axis crystals becomes irregular (tilt angle of approximately 1°), and additional crystals are unnecessarily formed in areas where the laterally grown GaN regions come into contact with each other. Employment of the air gap structure of the present invention greatly alleviate the above problem. As a result, particularly in a light emitting diode that emits in the ultraviolet light region and that has a small percentage of In in the active layer 17, the luminous efficiency (i.e., emission intensity at a given applied current), can be increased and current leakage can be decreased.

[0026]

The second characteristic is that, because air gaps are formed beneath the crystal layer structure that forms the light emitting device, the light emitted from the active layer 17 is efficiently reflected to the front surface of the crystal (p-electrode side), and this improves the light emission efficiency. In conventional ELC structures, an SiO_2 dielectric film is used as a substance corresponding to the air gaps of the present embodiment. Since the SiO_2 dielectric film has a refractive index similar to GaN-based compound and greater than air, a larger amount of the light emitted from the active layer passes through the sapphire substrate side, scatters, and is absorbed, reducing the light emission efficiency in comparison to the present embodiment. The reflectivity of the interface between GaN and air is twice that of the interface between GaN and SiO_2, and therefore the efficiency of light emission from the active layer can be greatly increased. Furthermore, in

conventional ELO techniques, because the laterally overgrown crystal is in contact with the mask for use in selective growth, the light from the active layer is reduced due to light scattering caused by the low crystallinity portion deposited on the polycrystal precipitated on the mask, and due to light scattering caused by the tilt of the wings in the area where the wing regions come into contact with each other. By employing air gaps as in the present embodiment, it is possible to reduce the influence of the polycrystal or tilt of the wing on the mask. In the present embodiment, as described above, the back surface of the wing region facing the air gap is mainly composed of N atoms, and is atomically flat. Therefore, it is possible to effectively reflect light emitted from active layer. In the prior art ELO techniques, the back surface of the wing and mask come into contact with each other, and therefore it is impossible to obtain an atomically flat surface due to the stress and/or polycrystal deposited. Accordingly, the effects achieved by the conventional techniques and that of the present embodiment are fundamentally different.

[0027]

Fig. 3 shows the relationship between the emission intensity and applied current in a light emitting diode of the present embodiment. The p-type electrode serves as an emission detection surface. The light emitting diode of the present embodiment exhibits a greater emission intensity at any given applied current, since the light emitted toward the sapphire substrate is efficiently reflected and transmitted from the p-electrode.

[0028]

The third characteristic of the present embodiment is that at least one of the p-electrode and n-electrode is so structured that, in the region to which a gold wire 23 serving as a means for supplying electric current is attached by wire bonding, the width of the concave portions of the u-GaN layer 12 is narrower than the region in which wire bonding is not conducted. This enhances the mechanical strength of this

portion. Thereby, damage to crystals in the vicinity of airbridges caused by the impact of the wire bonding can be prevented. Since there is no active layer in the region beneath the electrode and this region is not involved in emission of light, airbridges in this region are less influential on light emission than the region beneath the p-electrode. Therefore, narrowing the width of the concave portions is effective for strengthening the structure. With respect to the p-electrode, to enhance the light emission efficiency and to reduce the density of crystal defects, the larger the airbridge region, the better; however, when the airbridge region is too wide, mechanical strength is weakened. This causes damage to crystals due to the impact of wire bonding, reducing the yield. Therefore, it is preferable that the width of the concave portions forming the airbridges be narrow in the region where wire bonding is conducted. To maximize the effects achieved by the first and second characteristics of the present invention, it is preferable that the region in which the width of the concave portions is made narrower be the minimum necessary for conducting wire bonding.

[0029]

To prevent damage to crystals due to the impact of the wire bonding, a structure as shown in Fig. 2 can be employed. As shown in Fig. 2, when a u-GaN seed crystal layer 25 is formed, the width of the concave portions is made uniform in all regions and only the width of the ridge portions of the seed crystal is made wider in the region where wire bonding is conducted. In other words, in the $Al_UGa_vIn_wN$ $(u+v+w=1)$ on the substrate, air gaps are formed in all regions except for the region beneath the portion in which a wire for supplying electric current is formed. The width of the concave portions is 12 μm, the width of the ridge portions of seed crystals in the region beneath the portion where wire bonding is conducted is 6 to 12 μm and in the region where wire bonding is not conducted is 3 μm. As with the structure shown in Fig. 1, this structure makes it possible to improve luminous efficiency by reducing the density

of crystal defects, to improve light emission efficiency by using airbridge, and to prevent reduction of the yield caused by the structural damage due to the wire bonding.

[0030]

In the present embodiment, the GaN layer is regrown to form airbridges using the GaN layer as seed crystals; however, at least one of the seed crystal layer and regrown layer may be made from mixed crystals containing Al, In, As, P, etc. When such mixed crystals are used, sometimes the selective growth becomes more difficult compared to the case where GaN is used; however, by having an air gap structure as in the present embodiment, even when the precipitates deposit on the mask for use in selective overgrowth, it is possible to prevent the laterally growing wing regions from coming into contact with the precipitates. As a result, high-quality crystals can be formed and the fabrication yield of the device can be enhanced.

[0031]

In the present embodiment, the GaN layer 12 that becomes a seed crystal is formed by two step growth using a low-temperature buffer layer as an intermediate; however, so long as it is a single crystal that serves as a seed crystal, other methods can be employed. In forming the ridge portions in the seed crystals, the lift-off process was employed; however, the formation method is not limited to this, so long as it can form a strip-shaped concave portion.

[0032]

In the present embodiment, light emission efficiency of the light emitting device is described; however, similar effects can be obtained by applying the present invention to a white light-emitting device that emits white light by exciting a fluorescent material that is disposed around the light emitting device using ultraviolet to blue light emitted from the light emitting device. Employing a semiconductor light emitting device of the present invention increases the luminance and fabrication yield thereof.

[0033]

[Effect of the Invention]

As described above, according to the method for fabricating a nitride based semiconductor of the present invention, by providing air gaps, it is possible to prevent the selectively and laterally overgrown wing regions from having irregularities in the orientation of the azimuthal axes of the c-axis crystals. This makes it possible to obtain a high-quality crystal that has very little defects and a regular orientation in all regions other than the ridge seed crystal region (entire wing region). This makes it possible to obtain a reliable light emitting device that achieves a high luminous efficiency. In particular, for light emitting devices that emit in the ultraviolet light region and have a small percentage of indium in the active layer, the luminous efficiency can be increased and current leakage can be decreased by reducing the density of crystal defects in the entire wig region.

[0034]

In the method for fabricating a nitride based semiconductor of the present invention, because air gaps are formed beneath the crystal layer structure that forms the light emitting device, the light emitted from the active layer is efficiently reflected to the front surface of the crystal (p-electrode side), and this improves the light emission efficiency. This structure increases the emission intensity of a light-emitting diode that emits in the blue to ultraviolet light region having an emission detection surface at p-electrode side compared to conventional devices using ELO, etc.

[0035]

According to the method for fabricating a nitride based semiconductor of the present invention, it is possible to strengthen the structure by making the width of the concave portions of the u-GaN seed crystal layer narrower in the region to which the gold wire is attached by wire bonding compared to the region in which wire bonding is not conducted, or by making the width of the concave portions identical in the entire region

and making the width of the ridge portions that serve as seed crystals wider in the region in which wire bonding is conducted. Damage to crystals in the vicinity of airbridges caused by the impact of the wiring can be thereby prevented. This significantly improves the assembly yield while conducting wire bonding of nitride based semiconductor light emitting device having air gaps.

[Brief Description of the Drawing]

Fig. 1 is a cross-sectional view of a nitride based semiconductor light emitting device according to one embodiment of the present invention.

Fig. 2 is a cross-sectional view of a nitride based semiconductor light emitting device according to another embodiment of the present invention.

Fig. 3 shows the improvement in luminous efficiency of the present invention.

Fig. 4 is a cross-sectional view of a conventional nitride based semiconductor light emitting device.

Fig. 5 is a cross-sectional view schematically showing a conventional technique for achieving few defects.

[Explanation of symbols]

11 sapphire substrate
12 u-GaN seed crystal layer
13 u-GaN layer
14 u-GaN layer
15 n-GaN layer
16 u-GaN layer
17 InGaN active layer
18 p-AlGaN layer
19 p-GaN layer
20 p-electrode
21 base electrode
22 ball
23 gold wire
24 n-electrode
25 u-GaN seed crystal layer

41 sapphire substrate
42 u-GaN seed crystal layer
43 u-GaN layer
44 n-GaN layer
45 u-GaN layer
46 InGaN active layer
47 p-AlGaN layer
48 p-GaN layer
49 p-electrode
50 base electrode
51 ball
52 gold wire
53 n-electrode
54 dielectric masks
55 sapphire substrate
56 GaN
57 SiO_2
58 GaN layer
59 low-dislocation region
60 high-dislocation region
113 air gap

[Document name] Drawings

Fig.1

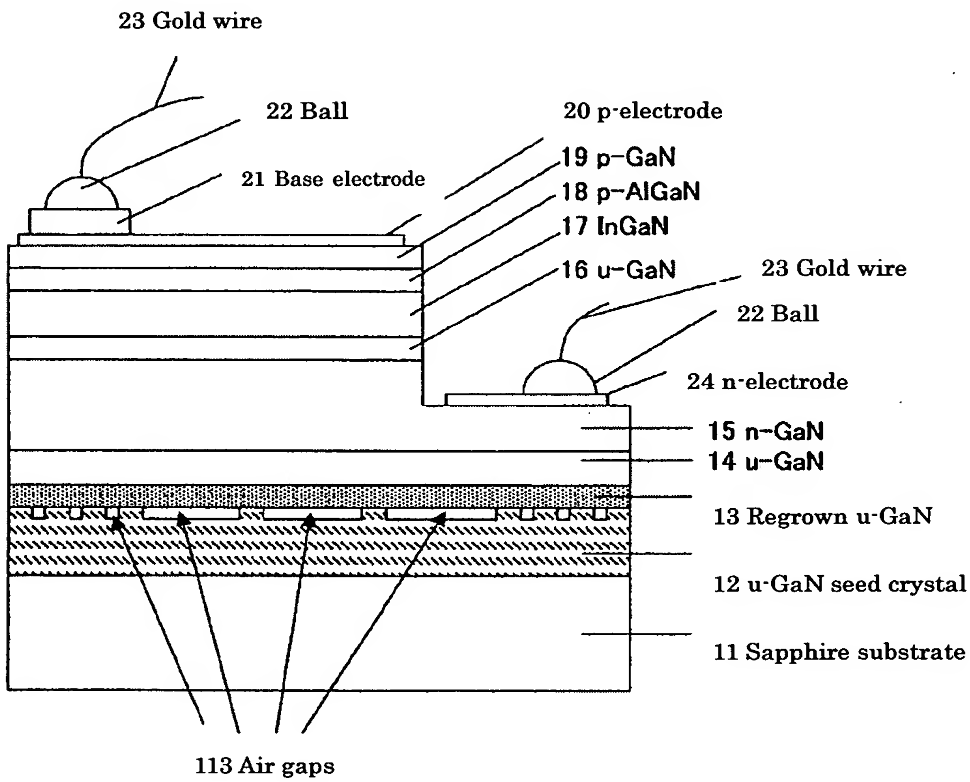


Fig. 2

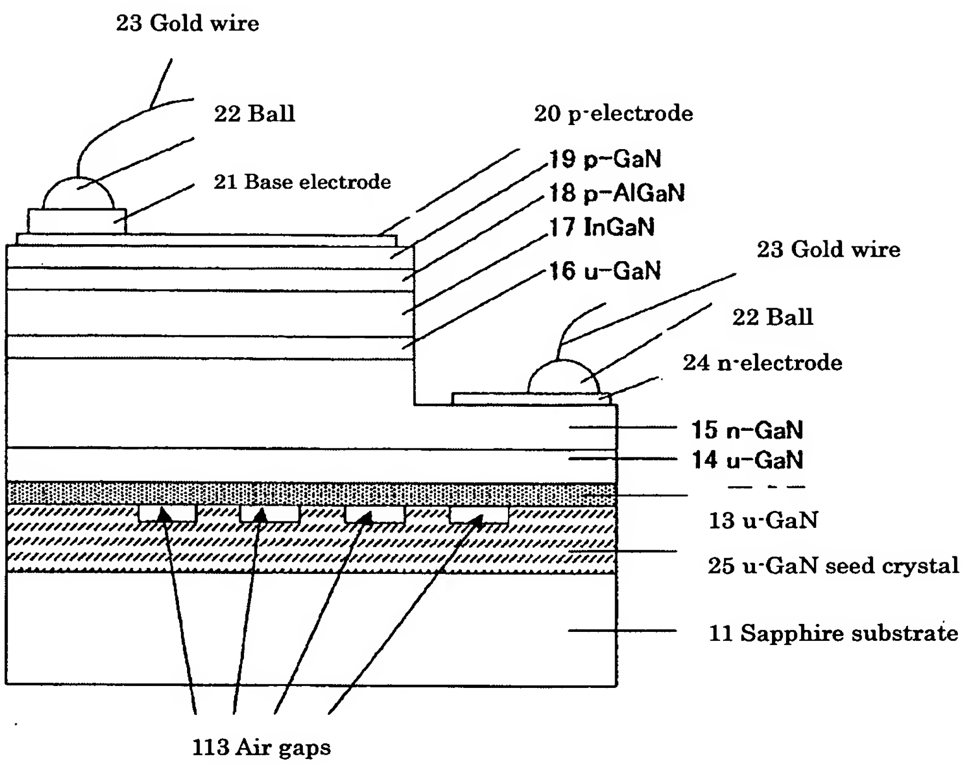

23 Gold wire
22 Ball
21 Base electrode
20 p-electrode
19 p-GaN
18 p-AlGaN
17 InGaN
16 u-GaN
23 Gold wire
22 Ball
24 n-electrode
15 n-GaN
14 u-GaN
13 u-GaN
25 u-GaN seed crystal
11 Sapphire substrate
113 Air gaps

Fig .3

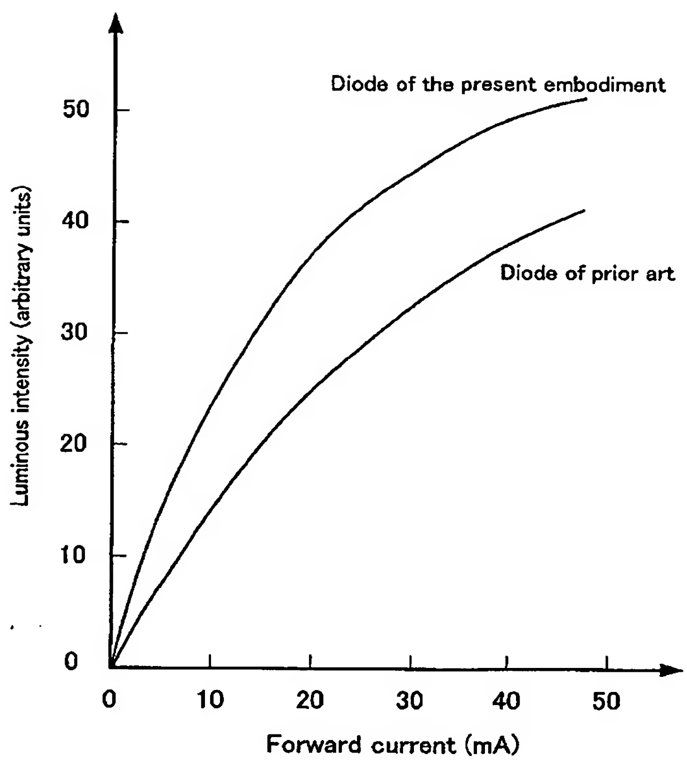

Diode of the present embodiment
Diode of prior art
Luminous intensity (arbitrary units)
50
40
30
20
10
0
0
10
20
30
40
50
Forward current (mA)

Fig.4

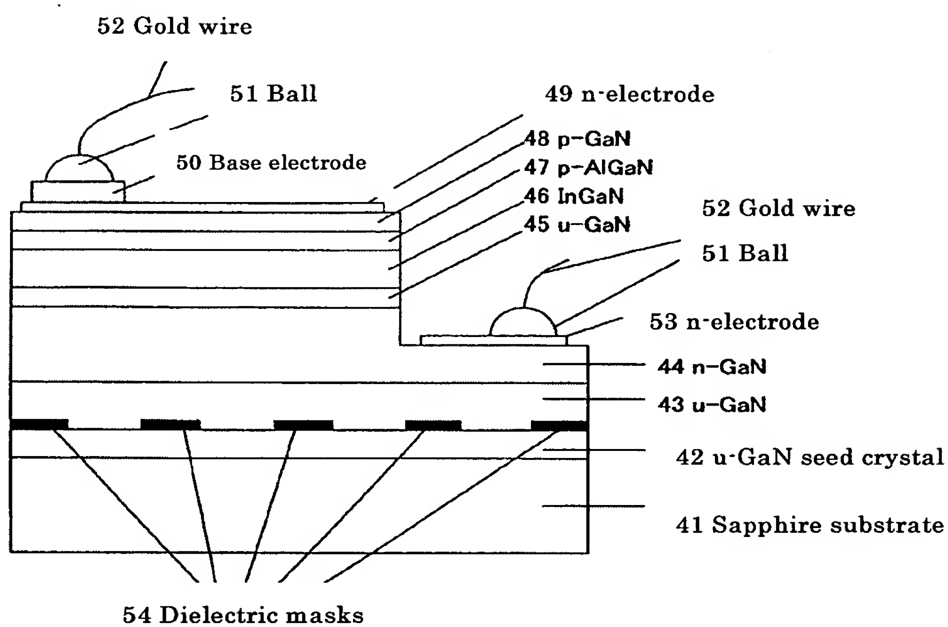
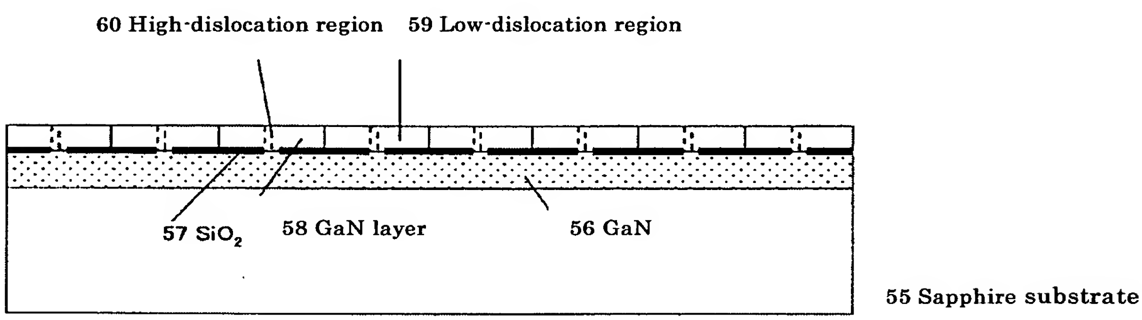

52 Gold wire
51 Ball
49 n-electrode
50 Base electrode
48 p-GaN
47 p-AlGaN
46 InGaN
45 u-GaN
52 Gold wire
51 Ball
53 n-electrode
44 n-GaN
43 u-GaN
42 u-GaN seed crystal
41 Sapphire substrate
54 Dielectric masks

Fig. 5


60 High-dislocation region
59 Low-dislocation region
57 SiO2
58 GaN layer
56 GaN
55 Sapphire substrate